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A Critical Study of the Recent
Experimental Literature
On Memory, with
Special Reference to its
Pedagogical Significance

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A CRITICAL STUDY OF THE RECENT EXPERIMENTAL LITERATURE
ON MEMORY, WITH SPECIAL REFERENCE TO ITS
PEDAGOGICAL SIGNIFICANCE.

by

D E B O R A H C H A S E A K E R S

THESIS FOR THE DEGREE OF BACHELOR OF ARTS
IN PSYCHOLOGY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Deborah Chase Akers

ENTITLED *A Critical Study of the Recent Experimental
Literature on Memory with Special Reference to its
Pedagogical Significance*

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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A CRITICAL STUDY OF THE RECENT EXPERIMENTAL LITERATURE ON MEMORY,
WITH SPECIAL REFERENCE TO ITS PEDAGOGICAL SIGNIFICANCE.

If, by our education, we are trying to develop the human mind and body to what it ought to be, we have been quite unscientific in our efforts. To a great extent the child has been left to discover its own methods of study. We seek to train, but too often not the best way of training. What have we demanded of our teachers? Seldom more than that they should have a certain amount of "learning" which may be entirely foreign to the developing organism of the child. To educate the child through its developing stages we must know both the causes that bring these changes about, and the normal courses that the mind would follow of itself.

This is the demand of pedagogy to-day. Time and effort are wasted where learning is left to accidental success, to uncontrolled planless efforts. To place learning on a more economical, scientific basis; to lead to a pedagogical improvement; wide and varied experiments have been performed for a better understanding of the memory function.

If this is the factor the teacher has to deal with, his problem is to understand its extent and limitations. He must measure it in each pupil in order to be able to treat each as it should be treated, to learn in the most economical way.

What has really been accomplished for teacher by the experiments? This is our problem.



It is by no means a simple task, to measure man's mental traits. It is difficult to determine upon a measure that is of any value for estimating the psychic states. The best we can do is to measure the returns to time and effort spent. And even here we have a problem; how are we to measure effort? Could we accurately measure the mental traits we would be able to say that one person differs from another in exactly what characteristics and to exactly what extent.

We can do this roughly, not accurately, but to a degree that is of great pedagogical significance. Our units are: time spent, repetitions needed, facts remembered, and kind and number of errors made. With these units we perform experiments with different methods of learning, and by the observation of memory under controlled conditions gain our insight into the memory function, and determine the best method of teaching.

CONDITIONS FOR EXPERIMENTS.

There are two kinds of conditions that must be governed, as far as possible, for accurate memory experiments in the laboratory.

In the first place the outer conditions must remain uniform and in the control of the experimenter. The experiments must be performed at the same hour of each day, in the same place, and with distractions reduced to the minimum. There must be no one in the room except the experimenter and the experimentee. They must be accustomed to working together, besides having special practice for the particular experiments in hand.

W. Lay (44) emphasizes the need of practice for the subject to be able to give valuable introspection. Before the experiments begin he should be trained in introspective ability. And care must be taken that the material be of uniform difficulty.

In the second place the inner conditions must remain as nearly the same as possible. The daily life of the experimenter should be kept regular, without excitement. The attention must be keyed up to the same point each time or the experiment is of no value.

Even with the utmost care the conditions cannot be kept wholly uniform; so we take the average of the results of experiments made in the same way a number of times. The experiment should extend over weeks and months, and new material used each day, but material of the same kind. Then at the end the results can be averaged up on a definite principle.

But not all of our experiments have been performed in the laboratory. Most of the experiments with school children have been performed in the schools. Here the conditions cannot be regulated accurately, but the results are valuable because with so many subjects the conditions average up to the normal. The factor most considered in these school experiments is the age of the pupils; sometimes the relative rank in class, and the sex. In experiments of this class we have usually measured ability by comparison of groups of different ages. We first find the general ability and then, from this normal, the variability for the different ages.

MATERIAL

Ebbinghaus (25), who made the first important experimental study of memory, chose nonsense syllables as material offering the most uniform difficulty. With this artificial material there were fewer associations and complications possible. He formed 2300 syllables and shuffled them together. They were drawn by lot and formed into series of different lengths. Several of the series were used at each experiment. This material has certain distinct advantages: (1) it is relatively simple and homogeneous, while prose or poetry changes in character and varies in interest with the individual apperception; (2) it affords an inexhaustible amount of new combinations of similar character; (3) it offers means for convenient quantitative variation.

Ebbinghaus (25) compared the process of learning a series of 12 nonsense syllables with that of learning a stanza of Byron's "Don Juan." The material was read aloud repeatedly until it was just possible to recall it voluntarily. This end was considered attained when, the first of the material being given, the whole could be repeated by heart for the first time without hesitation, at a given rate of speed, and with the consciousness of perfectness! The following table gives the number of repetitions necessary to make mastery perfect.

<i>Successive Days.</i>	<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>	<i>V</i>	<i>VI</i>
<i>Nonsense Syllables.</i>	16.5	11.0	7.5	5.0	3.0	2.5
<i>Significant Stanza.</i>	7.75	3.75	1.75	0.5	0.0	0.0

He estimated from his results, that only about one tenth the number

of repetitions are required for learning material connected by bonds of sense and rhythm.

Mary Whiton Calkins (20) performed some memory experiments with 50 college students of Wellesley. She compared different kinds of material for immediate and delayed recall.

Words were pronounced staccato fashion to the subjects: chair, lock, fan, slate, rug, box, match, tub, cloud, stamp. Words and pictures shown were projected upon a screen by the oxy-hydrogen latern. The words shown were: door, foot, cave, horn, sail, bowl, ring, fork, nail, lamp. They were shown one after the other. The pictures of objects were: scissors, book, brush-broom, inkbottle, clock, hat, knife, candle, flat-iron, vase. These were shown on the screen one by one. The time was regulated by a pendulum. Four seconds after the conclusion of the series the command to "write" was given.

Miss Calkins compares her results with results of similar experiments performed by E. A. Kirkpatrick (37) with 150 college students. But Kirkpatrick used real objects instead of pictures of objects, and found greater advantage with the "concrete" than did Miss Calkins. According to Kirkpatrick (38) the order of increasing effectiveness is : (1) names of objects, (2) mental pictures of objects, (3) real pictures of objects, (4) the objects themselves.

The following table compares the results of the two experimenters.

EXPERIMENTS BY MISS CALKINS.

	Auditory Works.		Visual Works.		Pictured Works.	
	Remembered	R. in order	Remembered	R. in order	Remembered	R. in order
Immediate Recall.	84.2	66.3	89.8	78.4	93.5	76.2
Delayed Recall.	34.9	14.3	48.2	24.6	74.5	32.0

KIRKPATRICK'S EXPERIMENTS.

	Auditing Works. Remembered	R. In order.	Visual Works. Remembered	R. In order.	Pictured Works. Remembered	R. In order.
Immediate Recall	72.0	—	72.8	—	85.6	—
Delayed Recall.	17.9	—	32.2	—	64.4	—

Both found the superiority of concrete over verbal; and both found the importance of the proper choice of material to be under-estimated rather than over-estimated by experimenters. These facts are brought out more strikingly in the case of delayed recall.

The 'delayed recall' is surpassed by the 'immediate' for every subject, except in 8 cases of concrete memory and in 2 of verbal memory in which there is no difference.

Almost as large a per cent of visual words as of concretes is recalled 'in order', but only about one half the number recalled are recalled in order. The 'order' of concrete objects is as well or better remembered by 5 subjects. By 4 subjects the 'order' of words is as well or better remembered after 2 days interval. By all the others, words and pictures immediately recalled are remembered better, even in their order.

The memory for visual words is significantly stronger than for words pronounced or heard.

In all cases the first of the series is best remembered, the middle the least accurately remembered, and, what is surprising, the last seems to have little or no advantage.

IMMEDIATE RECALL.

Percent Recalled	Auditing Works. Remembered	R. in order	Visual Works. Remembered	R. in order	Pictured Objects. Remembered	R. in order
100	14	9	17	15	28	14
90 or 89	16	7	20	10	12	3
80 or 78	7	5	8	7	8	13
70 or 67	7	9	6	6	1	5
60	4	2	0	2	0	2
50 or 55	1	2	0	5	0	4
40 or 44	1	7	0	2	0	6
30 or 33	0	6	0	3	0	2
20 or 22	0	2	0	0	0	0
10 or 11	0	1	0	0	0	0
0	0	0	0	0	0	0

<u>DELAYED RECALL.</u>						
	<u>Auditory Work.</u>		<u>Visual Works.</u>		<u>Pictured Works.</u>	
<u>Percent Recalled</u>	<u>Remembered</u>	<u>R. in order.</u>	<u>Remembered</u>	<u>R. in order.</u>	<u>Remembered</u>	<u>R. in order.</u>
100	0	0	2	2	2	1
90 or 89	1	0	5	1	10	1
80 or 78	2	1	1	1	20	1
70 or 67	4	0	3	1	7	1
60	2	1	6	0	1	4
50 or 55	6	0	8	2	5	4
40 or 44	8	5	10	4	2	6
30 or 33	9	3	5	8	2	8
20 or 22	6	7	7	8	0	8
10 or 11	5	12	2	13	0	10
0	7	21	1	10	0	5

While nonsense material has been very generally used in memory experiments, other materials have been more or less extensively employed. Prof. Kennedy (36) divides the material used in experiments into two classes, simple and complex. Under the head of simple material come: Intensity of Light, Intensity of Sound, Pitch of Sound (H. K. Wolfe, Merkel, Starke, Tschisch, and Lehmann have experimented with this material), Localization through Touch, Space Relations, Pressure, Muscular Sense (E. A. Hayden), Active Movements (T. L. Smith), Geometrical Figures through Vision (Warren) Color (L. Von Kreis and E. Schottlius), and Time. Under the head of complex material come : Sentences, Words, Syllables, Numbers and Letters, Concrete Objects, Prose, and Poetry.

Ebbinghaus (25) found the advantages in nonsense material over the other materials.

METHODS OF TESTING MEMORY.

We have considered the conditions necessary for memory experiments and the different kinds of material to be used in the

experiments. We must next consider the methods of testing memory. There are four different methods that can be used.

The method of Reproduction consists in making the subject reproduce his impression. This is the method generally used; for it follows our most natural, ordinary procedure. Binet (11) criticises this method as requiring a "translation of transposition of the impressions," and because a special aptitude would greatly modify the results. He thinks it should be reserved for verbal memory. But he has somewhat overestimated this side, for the experimentee will give the reproduction in the terms most natural for him. There will seldom, if ever, be an effort at translation of the impressions.

The Method of Relearning, or Ersparnismethode as the Germans more accurately call it, consists in finding the per cent of time and repetitions saved in the relearning over the original learning. The strength of the impression left in memory can be measured indirectly by the saving of time and energy required for the relearning of the material. Ebbinghaus (25) made 70 experiments --double experiments--, first with the emphasis on repetition and next with the emphasis on concentration. Each experiment consisted of reading or repeating six 16 syllable series a definite number of times, and then in 24 hours recalling them. The experiments were divided into 7 groups of 10 experiments each. The results are given in the following table, the number being the number of seconds required for the relearning.

	After 8 Repetitions	After 16 Repetitions	After 24 Repetitions	After 32 Repetitions	After 40 Repetitions	After 53 Repetitions	After 64 Repetitions
	1171	998	1013	736	708	615	530
	1070	795	853	764	579	579	483
	1204	936	854	863	734	601	499
	1180	1124	908	850	660	561	464
	1246	1168	1004	892	738	618	412
	1113	1160	1068	868	713	682	419
	1283	1189	979	913	649	572	411
	1141	1186	966	850	634	516	397
	1127	1164	1076	914	788	550	391
	1139	1059	1033	975	763	660	524
Mean	1167	1078	975	863	697	585	454
Probable Error	±14	±28	±17	±15	±14	±9	±11

The average time for the first learning of 6 series of 16 syllables each, as estimated from 53 experiments, was 1270 seconds, with the small probable error of 7. Comparing with this the time required for relearning as given in the table, Ebbinghaus estimates that on an average in relearning there is a saving of $1/3$, due to the persisting after effect of the repetitions.

The method of Association, or Treffenmethode, has been used less widely. Here the first or a part of the material is given to the subject and he fills in the rest by means of the associations with the part given.

The method of Recognition may be divided into two narrower methods, according to Binet (11) and others:

(a) In the Method of Selection the subject is given a number of impressions, among which is the original one, which he is to recognize and distinguish from those in company with it. But the attention is naturally drawn towards the centre of a series when we have to make a choice from among a set of objects.

(b) In the Method of Comparison the experimentee is to compare the remembered impression with another impression presented to him, and pronounce the latter as "equal, greater, or smaller" with reference to the first.

Totally different memory curves will most probably be the result for these different methods, even if the same sort of material is used in each set of experiments. Ebbinghaus (25) used the Ersparnismethode and found an immediate, rapid falling off of memory. In some recent experiments performed in the psychological department of the University of Illinois, the reproduction method was used and memory was found to be at its best 24 hours after the learning of the material.

IMAGINATIVE TYPES.

People vary greatly in the manner in which they recall. This has caused some investigators to consider experiments along this line as useless; but these differences are very important; through them we discover the different types of working memory.

Meumann (50) considers two main differences in people, in rapidity of learning and in the exactness and lastingness of retention. The one who learns quickly is different in the manner of learning, and in retention from the one who learns slowly. The "quick one" has the better immediate memory.

An experiment was tried with series of 12 nonsense syllables. The quick man learned them with 18 repetitions, while the slow man needed 56 repetitions. After 4 weeks' practice in learning nonsense syllables, the quick man needed only 6 repetitions, and the slow man needed 25.

But the one who learns fast forgets fast. It seems to be mere direct repetition of the sense impressions; if anything came between the reading of the impression and the reproduction, the memory would be wholly or nearly gone. The slow man stops to

organize the material, and then gives it slowly but more surely than the quick man, and he can give it later as well as immediately.

There is also a difference in intensity and extent of attention with different people. Some busy themselves with many things, some with few things but give more intense attention to them. The greater the intensity, the less extended the attention, and vice versa. Meumann makes a great deal of these differences. He (50) says they lead people to the different vocations. The one who can easily adapt himself can attend to a great number of things and can be a journalist, physician, teacher, artist, etc.; while intensive attention makes the scientist.

These qualities can be developed together, but we do not generally find it attended to. The slow man has the less broad but deeper concentration, and wins in the end when the work is long continued. So far in considering types of people we have dealt with the different learning types. There are also different memory types.

Charcot was the first to discover the different memory types. He considered the visual, motor, and auditory types. Meumann (50) says most people are acoustically-motor minded; i. e., they think in sounds and movements, but seldom the one without the other. Women have been found to be more visual than men, and children entirely visual, but Meumann (50) and other experimenters have found that they differ in about the same proportion as grown ups.

The visual minded sees the whole, and at the same time in all of its parts. He can reproduce the material backward almost

as well as forward. The auditory sees piece by piece, in succession, one calls for the next. Finzi (27) and Meumann (50) have discovered the visual minded to be slower, but surer and most lasting; he seldom, if ever, makes a mistake in his memory work. The acoustic-motor is quicker but less accurate. This type of person remembers each impression singly, in succession. Meumann has days and weeks in which one predominates and then the other.

Through results in failures of memory we can best see to what type the individual belongs. But for any degree of certainty concerning the type, there must be (1) repeated measurements under (2) carefully regulated conditions.

Cohn (21) performed experiments to ascertain what part is played in memory by the visual, auditory, and motor senses. 12 consonants arranged in 3 rows were presented in each case to the subject. In one group of trials the subject was requested to read the letters aloud, in another to repress articulatory movements while learning, and in 3 other groups to pronounce a series of vowels or numbers while reading the consonants.

There was a pause of 10 seconds between the memorizing and the reproduction. The subject filled this by repeating the numbers 1 to 20. There were 13 subjects engaged in the research, and each performed from 12 to 50 experiments.

From his results he draws two facts that he has proved effectively:

- (1) Where memory is based on auditory-motor images it is more extensively interfered with by an auditory-motor disturbance than a visual would be.
- (2) When the disturbing elements have an auditory-motor

character an increased use is made of the visual factors in memory wherever possible.

T. L. Smith (65) performed a series of experiments having to do with muscular memory. His material was nonsense syllables, and his purpose to compare the series learned normally with series learned when the articulatory movements were inhibited.

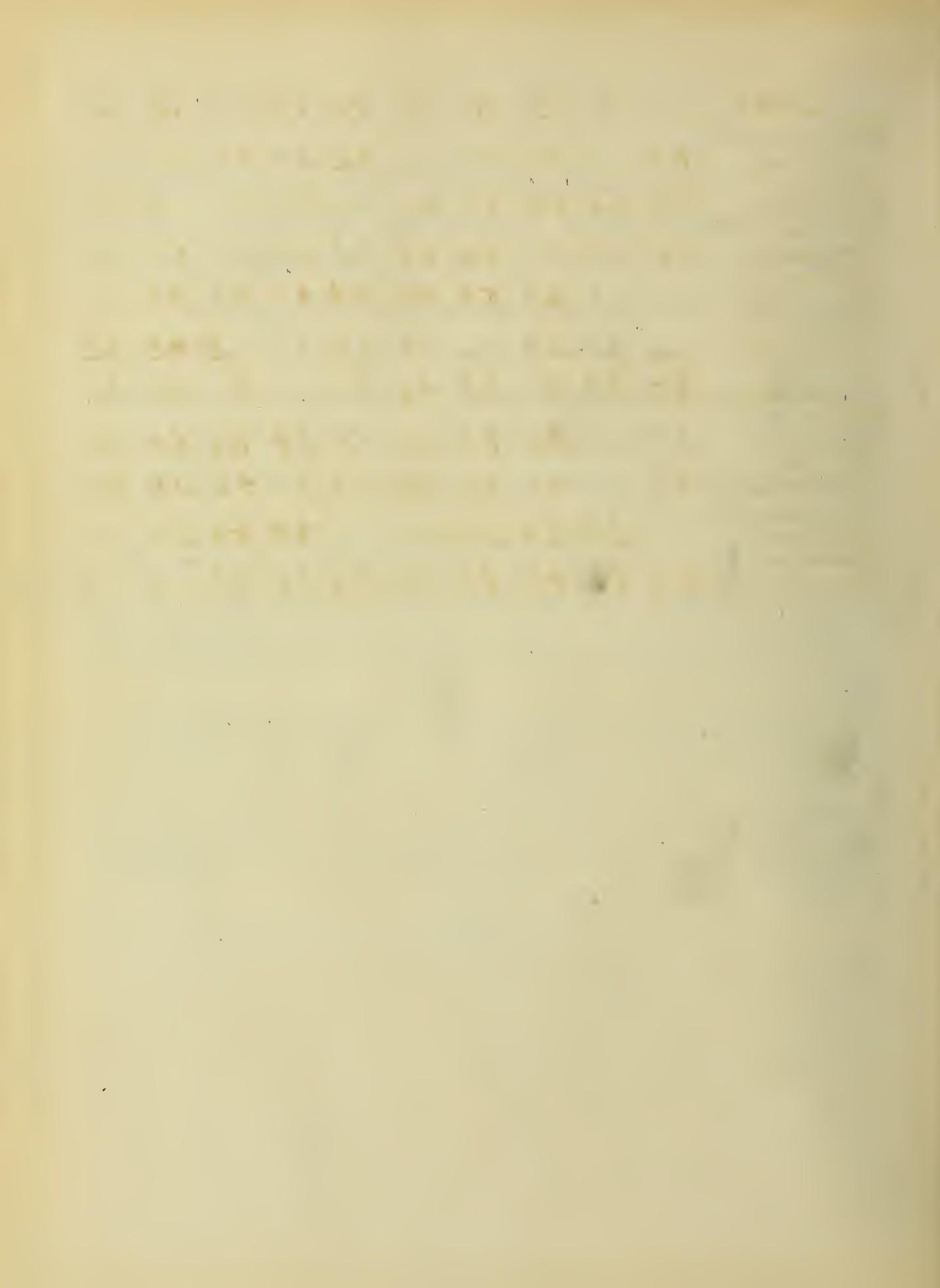
As a preliminary he tried 100 experiments with the subject memorizing while counting aloud - 1, 2, 3, 1, 2, 3, 1, 2, 3, etc., and the subject memorizing while sustaining a musical note.

He found counting to be the better method for inhibiting the action of the vocal muscles.

Practice was given to make the counting as automatic as possible, and daily hours of experimentation for each person were the same; for the memory varies greatly at different hours of the day.

At one sitting each subject was given 100 syllables; i. e. 10 series of 10 syllables each. It was found that a greater number of experiments caused fatigue. 10 series with counting were given on one day, and 10 series without counting on the following day. No series was ever repeated.

The following table shows the average of errors for the 10 series for each day.



		<i>Days</i>	<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>	<i>V</i>	<i>VI</i>	<i>VII</i>	<i>VIII</i>	<i>IX</i>	<i>X</i>
<i>Subject JHS</i>	Pronunciation											
	Inhibited	6.9	7.6	8.0	8.1	7.6	8.2	7.9	7.9	8.3	7.7	
<i>Subject SS</i>	Normal Conditions.	6.4	6.3	6.6	5.7	6.3	7.1	7.1	6.3	6.8	6.3	
	Pronunciation											
<i>Subject FHL</i>	Inhibited	7.2	6.4	7.9	6.6	6.9	5.7	6.1	6.8	6.3	7.1	
	Normal Conditions	6.4	6.1	6.0	5.5	4.9	5.4	4.9	5.6	4.7	4.9	
<i>Subject CG</i>	Pronunciation											
	Inhibited	6.6	5.7	5.8	6.1	5.9	5.6	5.3	4.5	4.8	5.2	
<i>Subject RC</i>	Normal Conditions.	5.0	5.3	4.1	3.5	4.1	5.0	3.5	4.2	3.0	4.2	
	Pronunciation											
<i>Subject RC</i>	Inhibited	7.9	6.9	8.5	7.7	7.2	7.8	7.4	6.9	6.8	7.6	
	Normal Conditions.	5.9	5.0	6.6	6.3	5.8	5.3	5.7	4.7	5.6	6.1	
<i>Subject RC</i>	Pronunciation											
	Inhibited	6.2	5.8	5.9	5.5	6.1	4.5	4.4	4.6	3.9	1.8	
<i>Subject RC</i>	Normal Conditions.	5.9	4.1	4.5	4.7	4.0	3.5	1.9	1.8	1.6	0.5	

A study of these tables shows in all subjects a gradual diminution of errors due to practice. But none of the five subjects exhibited the distinct types of visual, auditory, and motor memories so emphasized by Ribot and other experimenters, though two subjects showed a marked predominance of the motor element. By the addition of the counting the percentage of error was increased to an amount varying from 12.6% to 17.7% for different subjects.

In a second group of experiments, Smith (65) used the manual alphabet. A series of 5 was exposed for 20 seconds with 70 seconds intermission. In one series the subject was told to memorize visually; in another series the subject was required to form characters with his hand in addition to the visual reading.

In the results a decrease in percentage of errors was found for each subject when the characters were formed with the

hand while learning.

The motor must enter into memorizing, Smith concludes, "but this experiment has not been able to measure its exact influences and worth."

Ellen Bliss Talbot (72) tried to improve her visual memory. She tested her memory and found that she was predominately verbal-auditory, but also verbal-motor. She could command only general memory vision of an object, not details. Her direct visual memory was very defective. She could visualize dates but not words. When read aloud to, the impressions were verbal-auditory and verbal-motor.

In her practice work she tried to visualize a piece of poetry. She read lines of unequal length and then closed her eyes and described all the details she could remember. She also looked at pictures of Chinese figures and then told how they were arranged. She improved in ability to describe lines, from 6 or 7, to 20 or 25, and she only spent 1 1/2 to 2 hours a week for 7 months in the practice.

After 3 months she found herself visualizing words; later she visualized even words read to her. At the end of 7 months she found considerable improvement in her verbal-visual memory, and in her direct visual memory. The effect of the change was greater accuracy rather than increased speed of memorizing. She says she does not visualize any better now but more frequently; and the auditory and motor memories do not seem to have suffered any loss.

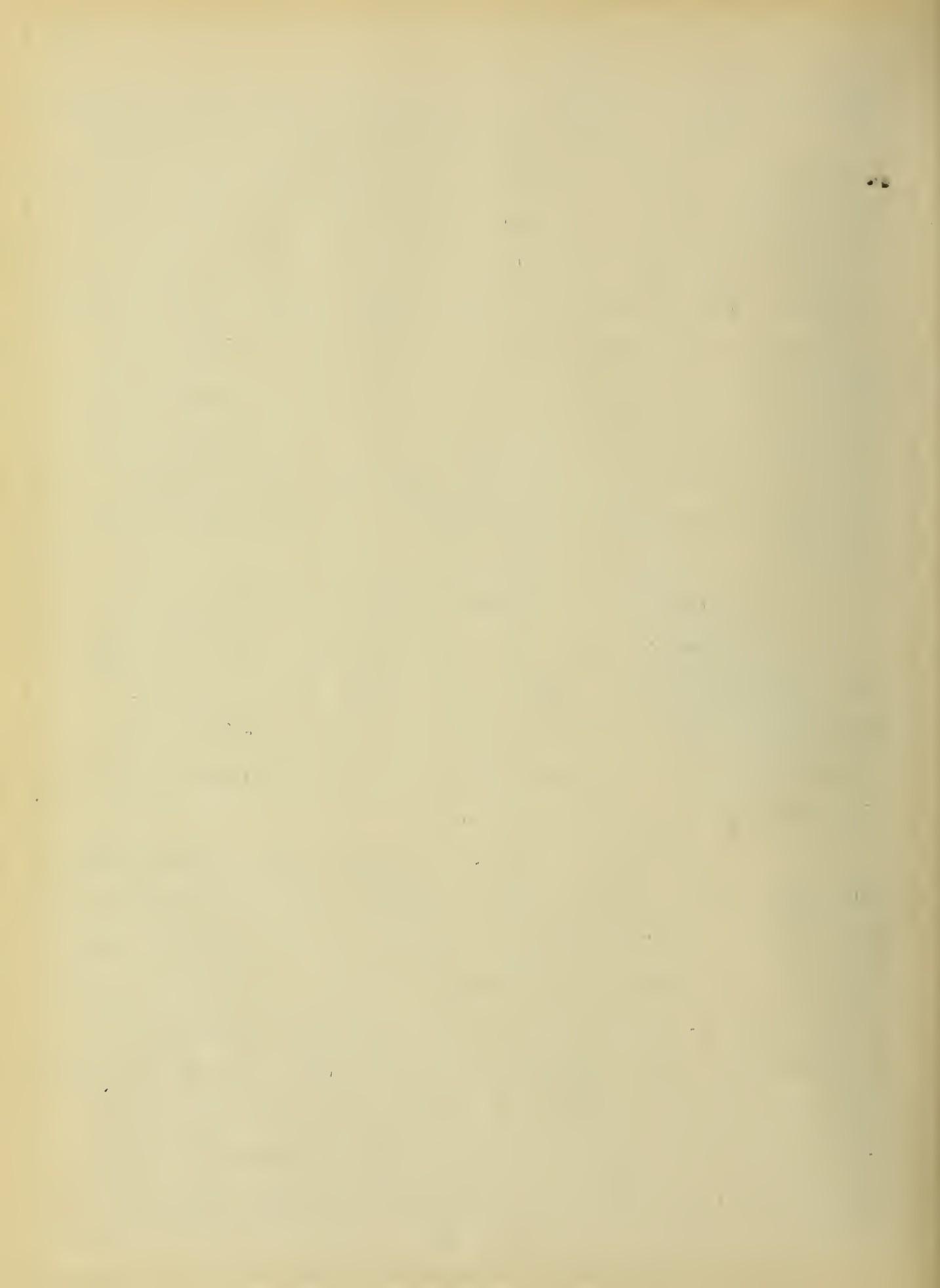
That a sense-memory can be developed is an important fact to pedagogy. And if so little practice is needed as Miss Talbot's

experiment seems to indicate, our problem is simplified inestimably.

Meumann (50) says the visual is ahead of all the other senses, rules the other impressions, and lasts over them. He tells of a painter who kept his model only one half hour, studying it intently during that time. He then dismissed it and painted his picture. Some artists have a visual image of every pencil stroke before they start their drawings; some have only a color memory. The different types are found in varying degrees. Binet believed that special memory depended upon the ruling interests and practice of the individual, and upon certain inherited paths of memory. But experiments performed by W. Lay (44) do not corroborate Binet's statement.

W. Lay (44) sent question blanks to 100 painters and sculptors of New York City, and then interviewed 25, to discover what part the conscious visualization played in their works. He found no very extraordinary power among them to visualize more vividly than people in general do. Some painters seemed to have the imagery developed very little.

Lay (44) also performed a series of experiments to determine the different memory images of people. He read to 100 juniors at Columbia, a short passage of a novel that took about one minute to be read, and that contained what he thought to be words likely to arouse in the minds of the hearers the mental images most noticeable in our every day life--sight and sound. Then the subjects wrote all they could remember of the passage, in any words they wished. From the number of words written that suggested mental images to Lay, he compiled a table that showed what percent of



visual and auditory images had been recalled. This supposed that what was recalled would be the easiest, and that the easiest to remember for each one would be that which most corresponded with the tendency of his mind. If he was eye-minded he would naturally remember the visual elements of the description; if ear-minded he would naturally recall the auditory elements. This method he called "indirect question," and he said the answers were very satisfactory. But he might have been more or less of one type himself and so interpreted the others.

In a second experiment he used the same method but had the subjects try to describe how they remembered, whether by the words, or by visual or other images. He notes in conclusion that the visual mental imagery is the more common form in which the reproduction takes place, but where the visual is not awakened the auditory comes in to help.

Lay says that when he wishes to speak in another language than English, the German comes first, and if he wishes to write, the French comes first. His German is speech motor and auditory; he learned it in Germany. His French is hand motor and visual; he learned it in school by reading and writing. Such analysis indicates that we may use a different kind of imagery in writing from that we use in talking or reading. In this case we can conclude with Miss Talbot that the faculty of imagery is susceptible to training.

We find experimental work on memory performed in Italy. Guicciardi and Ferrari examined 54 persons of both sexes between the ages of 6 and 67 years, to find from their verbal associations

to what type they belonged. Five suffixes were put one after the other on the top of a card, and the subject was given 10 minutes to write as many words as he could think of having those suffixes. It was thus a test of a person's rhyming abilities. The number of words written each minute was recorded in every case. After each experiment the subject was asked how he thought of the words he had written. The persons over 30 years were found to have the greatest facility for rhyming. The associations collected from all the subjects were classed as follows: Associations (1) by assonance, (2) visual, (3) ad literan, (4) ideative, (5) motor. If in any subject association by assonance predominated, he was characterized as auditory; if visual associations predominated, he was a visualist, etc.

This sort of experiment has not great scientific value, and yet the data collected have a certain worth that should be recognized. Lay's method in his experiments on Mental Imagery (44) was much the same as this method used by Guicciardi and Ferrari. Shaw (63) used a similar method. He told the story of a boy to 700 school children. This story was divided into 152 terms; and the purpose was to see what terms each would remember and by these to determine the type of the pupil; whether visual, motor, auditory, etc. Galton was the first experimenter to deal with "types" of imagery. He introduced the questionnaire method. Meumann (50) says the best method of determining the type of a person's memory is to note the interruptions and obstructions. Hindrances show the type of imagery directly.

Inaudi and Diamandi are famous calculators that have been

examined by Binet, Meumann, and other psychologists. Inaudi had no education; he did not know his alphabet. When given a long series of numbers he could repeat 42 when ordinary people could only repeat 13. But in the same sort of experiment with letters he could repeat only 6 or 7; and only a very few words of a poem. In his public performances he had his problems read to him. He was of the auditory motor type. He could solve two complicated number problems at once, and without special effort he could remember the figures on the following day. He always systematized his numbers, remembered them in successive rows, in sets. In the experiments performed with him in the laboratory, he was found to be predominately motor, but also acoustically minded. If he saw the numbers it bothered him. Singing a tone during the working of a problem took him double time, but he did not lose himself. The striking of a metronome did not hinder him, but with his tongue between his teeth he was three times as long in solving a problem. With his tongue clear out it took him four times as long. When he was hoarse he could not figure so well. An apparatus was used to measure the tongue and larynx movements, and weak speech movements were found.

Diamandi was visually minded. He saw the figures as if on a page before him. In his performances he first looked at the problem and then shut his eyes and put it into his own hand writing. Then, he said, the figures seemed to work out themselves. Binet gave him series of numbers written in colors, and it took him two readings to get them, one to get the numbers and the second reading to get the colors.

Inaudi worked quicker: the acoustic motor is quicker

than the visual. Inaudi worked immediately after he received the material. Diamandi had to wait to absorb it. In 45 seconds Inaudi knew 25 figures while Diamandi needed 3 minutes. But Inaudi had hard work with numbers presented to him visually, in groups, in a spiral form, etc.

The purely acoustic man is never found, but some are very near this extreme. Dodge thinks in both visual and motor symbols. He often speaks aloud but never hears himself. His inner thinking is a motor speech of life, tongue, mouth, and head movements. His whole family lack acoustic memory. He can not remember people's voices, nor a piece of music, but he can sing in himself in a motor way. After he has been to an opera he can go through it again in a motor way; it is a pantomime to him.

Meumann (50) tells of an idiot who could not speak intelligibly but who could repeat a melody he had heard once. Children understand tones sooner than words. Tracy says children often know musical tones when they are but 6 months old.

In general children think visually until they leave the grammar schools and girls are more visual than boys. Let children learn in the beginning according to their type, and then gradually bring in the other paths for memory. This is the important fact for pedagogy; this is one step toward our goal-economical learning.

METHODS OF LEARNING.

How shall we be able to learn with the least possible expenditure of time and energy? This is the problem of the schools; and this is the problem that memory investigators have attempted to

solve.

The Germans, who have done the most extended work in this field, have considered three methods of learning and have given these methods their names: der Ganz Methode, der Teil Methode, and der Vermittelnde Methode; i. e., the whole method, the part or fragmentary method, and the mediating method.

For example, we have a stanza of a poem to learn. Using the Ganz Methode the whole stanza is read through repeatedly until it is learned. According to the Teil Methode a fragment is taken, perhaps one line, and this is repeated over and over until it is mastered; then the next line is taken in the same way, and so on until the whole is learned. Between these two methods a third has been entered; a method that has the advantages of both the other methods. There are one or more drops of attention in learning extended material, and so the middle parts are not fixed in memory as well as the first and last. To remedy this the material may be divided up by observing pauses at certain places, or the hard part may be learned separately after the whole has been read over, and then the whole gone over again in the end.

Lottie Steffens performed experiments under G. E. Müller at Göttingen to discover the natural methods of learning. She performed experiments for 12 successive days with 6 adults and 1 nine year old boy. The boy was given two parts of 6 lines each, of a German poem. The others were given 2 verses of one of Byron's poems. They were to read and recite aloud until able to execute one errorless recitation; and they were to try to learn as quickly as possible. As the subject learned aloud, the experimenter underlined each word or phrase repeated, and made a vertical mark after

each repetition. So she got the length and succession of each part repeated.

She found that:

- (1) All divided the verse into parts.
- (2) All repeated the parts already learned, each time they learned a new portion.
- (3) All repeated the first lines oftener than the last ones. The boy used an entirely disproportionate amount of time.
- (4) The difficult parts were learned by special, separate repetitions.
- (5) The end of one part and the beginning of the next were connected by means of special repetitions.
- (6) Adults tried to recite what they had partially learned, and used the text to help. The boy read without trying to recite.
- (7) They read slower over the more difficult material. The boy learned the most erratically, wasting 21 repetitions on the first two lines and used only 6 for the last.

Then with the same persons she tried the two methods, the Ganz Methode and the Teil Methode. She used stanzas from Byron's Childe Harold's Pilgrimage, as her material, and found that, though the fragmentary method is the most generally used when each is left to learn in his natural way, yet the whole method is by far the more economical--less repetitions and less time. Des Bancels (24), Ephrussi, Pentschaw, (59), and others have also verified this.

Des Bancels (24) had adults learn a piece of 10 verses each morning under the same conditions, at the same hours. He had them use the Ganz Methode one morning and the Teil Methode the next.

When the Teil Methode was used there were 2 1/8 out of 10 verses correct. When the Ganz Methode was used there were 5 1/8 out of 10 verses correct. These were tests for immediate reproduction and reproduction six days later; time and repetitions were saved by the Ganz Methode, and fixation was better.

Des Bancels (24) also performed experiments on 6 school children between the ages of 9 and 12. The children were taken individually and studied. First they were given experiments to discover their natural method of learning, and then they were told how to learn by the Ganz Methode. Both their immediate and remote memory was tested.

Five used the Teil Methode naturally and 1 used the Ganz Methode naturally. 2 found the Teil Methode better, and 4 found the Ganz Methode the better for learning. In the end all found the Ganz Methode the better.

Des Bancels says in explanation of this, that with the Ganz Methode the sense must be considered; it is memory of ideas, not merely verbal memory; mechanical memory is excluded.

Ebbinghaus (25) investigated this problem of 'how to learn', and though he did not reach the same results as G. Müller, Miss Steffens, and others, his results are not contradictory to theirs. In performing his experiments his method was to read through the whole material, and then to read the first syllable and attempt to recite the series. At the first hesitation, the remainder was read, and the next recitation begun anew. Thus he really used the Ganz Methode.

Both nonsense material and significant material were used with the two methods, and it was found that time was saved

with the Ganz Methode. The average time for a verse by the Teil Methode was 3 minutes, 3.3 seconds, and by the Ganz Methode it was 2 minutes 47.4 seconds. There was a saving of 15.9 seconds. In similar experiments even a larger proportion of time was saved by the Ganz Methode, both with adults and children. But this advantage is not quite so noticeable with nonsense material.

Meyerhardt (49) offers the following considerations as partly explaining this remarkable advantage for learning by the whole method.

(1) Learning by the Teil Methode, after the piece has been learned, the connections between the various parts must be learned; work that is eliminated by the Ganz Methode.

(2) Learning by the Teil Methode we associate the end of each part with its own beginning instead of with that of the next following section. These wrong associations later on disturb recitation and must be repressed.

(3) The immediately following parts are associated, and the more distant parts also aid each other by association. We fix certain parts more firmly by noting their particular position in the whole. In the Ganz Methode each part is learned in its exact place, and not otherwise.

(4) There is uniform amount of effort expended over the whole in the Ganz Methode.

Meumann (50) performed experiments on school children to test whether it was better to learn material as a whole or in parts. He used poems of 4 verses as his material. He found that the greater the number of parts the less economical was the learning.

The nearer we approach to the Ganz Methode, the quicker and better we succeed. With adults, experiments showed that the more voluminous the material the greater the advantage of learning by the Ganz Methode. But with nonsense syllables this fact is not brought out so strikingly.

One subject learned each day for 10 days, 2 verses of Schiller's "Dido", using the Teil and Ganz Methode on alternate days. On an average there was a saving of 14.5 minutes in the Ganz Methode for this small material; and the verses learned by this method were retained longer and were recited with more confidence. The highest number of repetitions for the 2 verses learned by the Teil Methode was 33, by the Ganz Methode 14. And verses learned by the Ganz Methode required less time in relearning.

Another subject learned 2 groups of material of 5 verses of 8 lines each, by the 2 methods. With the Teil Methode he needed 45 repetitions, with the other method only 12, but he used the same amount of time in both. He did not save time but he saved repetitions.

Both in learning and in relearning, the whole method is the economical method. The associations formed are always the same; they do not need to be changed; and the sense is followed and helps hold the material together.

Meumann (50) thinks the piece method is best for children at first, because they are spurred on by seeing their progress; they feel their advance in the piece method. But as soon as the child can be shown the advantages of the whole method, he learns better with it. Younger children are handicapped by becoming fatigued easily. A boy of 8 years learned verses of Goethe's

Erlkönig and needed 17 repetitions with the piece method and only 11 with the whole method.

Meumann says that the Ganz Methode is best for every kind of material: dates, names, and even material that forms an unconnected whole, as vocabularies of word pairs, etc. The Ganz Methode is the economical method.

Ephrussi does not entirely agree with this, but he measured only the time needed for learning. He performed experiments at Göttingen with 24 subjects, 15 men, 6 women, 3 girls of 13, 15, and 16 years. In life we often have to learn data in pairs, historical events and dates, foreign words and those of the mother tongue, etc. The problem in this experiment was to find which is the better method for learning pairs of nonsense syllables. The subjects worked for 1 hour daily from 8 to 36 days. They tried 2 methods: the Ganz Methode, reading and rereading the whole; and learning by pairs, repeating each pair till learned. This latter method is called the "cumulative method."

In conclusion Ephrussi notes that (1) for normal concentration of attention the "cumulative Method" is better, but (2) when attention is defective the whole method is more advantageous.

When a mixed material was used, each pair composed of a German word of 2 syllables and a number of 3 figures, learning by the whole method proved a decided advantage.

Ephrussi explains his results in this way : the learning process consists of 2 psychic processes, (1) familiarizing oneself with each part of the material and (2) associating the parts. The formation of associations between the parts of memory material

begins only when the material is a familiar one, or has reached a certain degree of familiarity. That method will then be best that produces this familiarity with the least number of repetitions. In the "cumulative method" for a vocabulary, 6 repetitions bring the second component of the pair after the first 6 times and before the first 5 times, thus establishing firmer associations.

In conclusion from this experiment we may note:

- (1) The more familiar the material the easier the associations.
- (2) In learning by pairs there are two kinds of associations to be considered, (a) association of the first with the second, and (b) the reverse, which leads, when the second part is given, to a reproduction of the first.
- (3) Of two methods, that one is more expedient which with less repetitions leads to a greater degree of familiarity.
- (4) In learning unfamiliar material the part method seems preferable.
- (5) In learning material that is familiar the whole method gives better results.

Pentschaw (59) performed experiments with the different methods of learning. Each experiment began with nonsense syllables and ended with rational material. He measured the time and repetitions for learning and relearning. In using the Teil Methode he divided the material into 2 parts, each part to be learned and then the whole gone over. The average from all his experiments was that 20 repetitions were needed in the Teil Methode, and 15 in the Ganz Methode. With the significant material there was more advantage in the Ganz Methode than there was with the nonsense material.

The disadvantage of the Ganz Methode is that the hard parts are not given fullest attention; and also that the attention is not uniform, but follows a curve, the first and last parts being strong. If the material to be learned is long, there will probably be 2 drops of attention. In such a case^a compromise method has been found to have the advantages of both the other methods. In this method lines or spaces are used to separate parts of the material; and then in repeating the material a pause is to be made at those places. But the subject does not go back to the beginning until the whole has been gone over. There are no false associations, and a maximum of concentration is caused by the pause and renewed attention for the following.

Another method is to learn the material as a whole, and on finding difficult places to mark them off and learn them separately, and then go over the whole again.

Ebert and Meumann compared the relative values of the 4 methods. They performed 3 series of experiments. Series I and III consisted of 8 groups, each of 4 lines of 12 syllables each. Series II consisted of but 4 groups. All 4 methods were tried in each group, a different method being employed for each line.

For the first the Ganz Methode was used; the line was learned as a whole. The Teil Methode was used for the second; the line was divided into 2 equal parts and each part learned alone before the line was read as a whole. The third was learned as a whole with a pause length of 1 syllable after the sixth syllable. In the fourth line 2 such pauses were made, 1 after the fourth and 1 after the eighth syllable.

Summarizing the results of this experiment we have a comparison of the relative values of the four methods.

(1) Each one of the old methods has its characteristic strong and weak points. The Teil Methode keeps up the full vigor and energy of attention, but allows irrelevant associations. The Ganz Methode forms only advantageous associations, and prevents mere motor recitation, but lets the attention drop at times, and the middle parts are not learned as well as the first and last.

(2) The Vermittelnde Methode combines the advantages of the other two methods and avoids their disadvantages. The attention is kept constant and no false associations are formed.

(3) The Vermittelnde Methode is quicker in leading to a first errorless recitation.

(4) The Ganz Methode results in more accurate and permanent retention and more confident reproduction.

(5) The Teil Methode effects relatively rapid learning but the retention is not reliable and it does not persist for any great length of time.

(6) The Vermittelnde Methode is conducive to rapid learning and to retention of medium permanency and reliability.

(7) In long continued exercises in mechanical learning the psychic effects of the various methods approach each other; the learner becomes more and more able to eliminate the inexpediencies of the different methods and utilize the advantages.

THE MEMORY FUNCTION.

The mechanical memory of children is considered to be better than that of adults, but this is due to the habits and

training of adults. They have grown accustomed to looking for reason, and find it hard to memorize nonsense material. Meumann (50) cites the fact that the child who could not understand the geometrical demonstration, learned it word by word more easily than the child who understood, and tried to learn word by word. The one had learned to remember reasonably while the other learned mechanically. Disuse of this mechanical memory weakens it.

Bolton (15) has shown that the age has more to do than the intelligence of the child, on the development of the memory. The older the person, the greater is his capacity for remembering.

The progress of the child from 1 to 5 years is rapid, then it is a little slower up to 14; then still slower to between 20 and 40, and then it retrogrades.

Bagley (5) divides the school life of the child into 3 distinct stages. (1) The transition stage is from 6 to 8. The factor that is most effective in this period is vivid portrayal dealing almost exclusively with concrete experiences. Repetition is important. Logical reasoning is entirely out of place. (2) The formative stage is from 8 to 12. In this stage repetitions strongly supplemented by vivid portrayal are the important factors. Symbols should still be closely associated with the concrete experiences for which they stand, but there is a place for the simple operation of logical reasoning in the later part of this period. (3) The adolescent stage is between 12 and 18. Organization and reasoning are the primefactors of this period. Yet there is a place for vivid portrayal and repetitions to enter as helps.

The child has different needs and different capacities

at the various stages of his growth, and these must be catered to for the child's best development. In order that the factors conditioning recall can be intelligently applied to the educative process these varying characteristics must be taken into account.

T. L. Bolton (15) investigated the growth of memory in school children, and the effect of fatigue caused by the school session. He used series of numbers not in natural order, and with no digit repeated, as his material. He read the material before the classes. Each class was tested twice in the morning at the opening of the school exercises, and twice in the afternoon just before the close of the session.

The digits were dictated slowly and distinctly, at intervals of about $2/5$ seconds, with care to avoid rhythm and grouping. At a given signal after the dictation the pupils wrote the digits as they remembered them.

In the lower grades of the High School 12 observations (groups of five or more digits) constituted a test. In the grammar schools the higher grades were given 9 observations, and the lower grades were given 3, at a test.

Bolton concludes from this test that the memory-span increases with the age rather than with the growth of intelligence of the child. Comparing the pupils classed as good, fair, and poor, for the same grades, the memory production pointed to the fact that good memory is not necessarily accompanied by intellectual acuteness--"the growth of memory does not necessarily accompany intellectual advancement."

He tabulates the results of his experiments as follows:

(1) The limit to the memory span for the pupils in the public school is 6.

(2) The memory span increases with age rather than with the growth of intelligence.

(3) The memory span measures the power of concentrated and prolonged attention.

(4) Intellectual acuteness, while more often accompanied by a broad memory-span and great power of concentrated and prolonged attention, is not necessarily accompanied by them.

(5) Girls have better memories than boys.

(6) With practice pupils increase in their ability to remember groups of digits.

(7) Pupils unconsciously remember digits that they heard a day before, when they are used a second time.

(8) The tests do not show that the pupils suffer fatigue from the day's work. This fact shows that the work in the schools is probably not excessive.

(9) Memory images pass through 3 stages in leaving the mind. First they suffer a confusion of order; second, a loss of certain elements and the substitution of associated elements; and third, a complete loss of some elements and no recovery.

F. Kuhlmann (29) has made this same division of stages for the fading memory image.

(10) Ideas previously in the mind and associative forms of ideas, are factors in causing the confusion of the memory image and its final loss.

(11) There is an apparent tendency to over-estimate the number

of ideas presented to the mind, when the number of ideas is slightly greater than the memory span; but the general rule is to underestimate the number.

(12) Ideas, except the last 2 or 3 in a series, are lasting in an inverse order as they are removed from the beginning of the series in which they occur. The last 2 or 3 are lasting in decreasing degree as they are removed from the end of the series.

Alexander Netschoeff of the University of St. Petersburg (54) made similar experiments in the grammar schools of St. Petersburg. He experimented with 687 children between the ages of 9 and 18. He made two tests, one in the first hour of the school session, and one in the first hour after recess.

His material was of 8 kinds:

- 1.- Twelve familiar objects were shown them; key, book, etc.
- 2.- Twelve inarticulate sounds were heard; tearing of silk, etc
- 3.- Twelve numbers over 10 and below 100 were read to them.
- 4.- Twelve words of 3 syllables expressing objects seen in every day life were read to them.
- 5.- Twelve words of 3 syllables calling up auditory concepts were read to them.
- 6.- Twelve words were read expressing temperature and touch sensations.
- 7.- Twelve words were read that were associated with affective states; hope, care, pleasure, etc.
- 8.- Twelve abstract terms were read, as space, etc.

The following table gives the results of the immediate reproduction by the children of different ages and with the

different materials. The percentage is on a basis of 10.

YEARS	9	10	11	12	13	14	15	16	17	18	19	
МАТЕРИАЛЫ	1	6.4	6.6	7.2	8.6	8.6	9.0	9.1	9.5	9.8	9.7	—
2	4.9	4.9	5.3	5.6	5.8	6.5	6.8	7.0	7.5	7.1	—	
3	4.4	4.7	5.2	4.8	5.2	5.7	5.3	5.9	5.2	5.3	—	
4	6.3	6.8	6.9	6.9	7.0	7.5	8.1	8.1	8.1	7.6	—	
5	5.2	4.7	5.5	6.2	6.3	6.8	6.7	7.2	7.0	7.0	—	
6	4.1	4.6	5.5	5.9	6.1	6.6	6.9	7.2	7.6	6.9	—	
7	3.0	3.1	4.1	4.8	5.6	5.9	6.2	6.6	6.7	6.3	—	
8	4.2	4.6	5.0	5.1	5.2	5.7	5.7	6.0	5.9	5.5	—	

In conclusion he observes:

- (1) All kinds of memory increase with age.
- (2) The memory for the different types of material differed with different children. The memory for numbers was weakest and the memory for objects, strongest.
- (3) The meaning of words had much to do with their retention.
- (4) The girls had the stronger memories. Between the years 11 and 14 there was the greatest difference between boys' and girls' memory.

The 18 years old were superior in general memory, but in mere mechanical memory the 9 years old were almost their equals.

Joseph Jacobs (33) experimented to find the normal limits of reproduction for different ages, with different materials. He first tried to use nonsense syllables, but found that they varied greatly in relative difficulty of pronunciation and in relative facility of rhythm. They were abandoned for letters and numerals. His subjects were girls of North London Collegiate School. The numbers and letters were read to the subjects at the rate of 2 a

second, in a monotonous tone. The reproduction was taken immediately

AGE	8	9	10	11	12	13	14	15	16	17	18	19
Subjects.	8	13	19	36	41	42	42	72	66	50	30	14
Average of numbers.	6.6	6.7	6.8	7.2	7.4	7.3	7.7	8.	8.	8.6	8.6	8.6
Average of letters.	6.	7.	6.6	4.6	6.5	6.7	6.7	7.4	7.9	7.3	8.2	7.9

If the span increases normally with age up to a certain point, it follows that a standard span can be found for the various ages and conditions. A standard that is relative, not absolute, but which enables us to ascertain whether a boy or girl is above or below the average.

Jacobs (33) performed experiments on idiots and found among the highest grades that their memory span was from 2 to 4. So we get the connection between high span and high place in form. This "span of prehension" is surely one test of mental capacity.

J. C. Shaw (63) confirms these same general facts; i. e. (1) Maximum memory is reached at a comparatively early age, about the beginning of the High School period. (2) The growth of girls' memory is more rapid than boys'.

Mrs. Bryant and Mr. Jacobs tested the powers of school children in reproducing numerals and letters after once learning them. The material was dictated in a monotonous tone at the rate of 120 sounds a minute. This experiment was similar to that of Joseph Jacobs described above. The reproduction was taken immediately. The "span," the ability measured by the maximum number of letters or numerals that could be repeated after once hearing them, showed a decided increase with the age of the pupils.

Boys of 11 years could repeat 6.5 numerals and 5.5 letters.

Boys of 12 years repeated 6.8 numerals, and 5.7 letters.

Boys of 13 years repeated 8.8 numerals and 7.9 letters.

The results for the girls were as follows:

AGE	8	9	10	11	12	13	14	15	16	17	18	19
Nº of Subjects.	8	13	19	36	41	42	42	72	66	50	30	14
Numerals-AverageNº	6.6	6.7	6.8	7.2	7.4	7.3	7.3	7.7	8	8	8.6	8.6
Letters-AverageNº —	6	7	6.6	4.6	6.5	6.7	6.7	7.4	7.9	7.3	8.2	7.9

We have yet two kinds of memory to consider, immediate and lasting memory. The aim of learning is not always to retain the material as long as possible; sometimes it is only to repeat it once. It would be an overloading to keep all details. We would be helpless in centering our attention. Meumann (50) asked students to describe minutely the rooms of their houses, and other instances of their daily life. He found that they only had rough general memories of these facts, and he draws the conclusion that repetitions of conditions as such, do not enforce retention.

E. A. Kirkpatrick (37) experimented to determine the relation between recognition and recall. We recognize things we could not reproduce, and this is better so, for it is all that is necessary in many instances. Kirkpatrick found that the power to recognize is almost double that of recall.

Both Kirkpatrick and Meumann state that immediate reproduction is better with older people than with children, in direct proportion to their ages. But this is probably due to mental grasp.

Ebbinghaus (25) performed 163 double experiments, each consisting of learning and relearning 8 series of 13 syllables each. The relearning was done at 7 different intervals, approximately:

$\frac{1}{3}$ of an hour, 1 hour, 9 hours, 1 day, 2 days, 6 days, and 31 days. The learning was continued each time until it was possible to repeat a series twice without error. This gave the relation of repetition to time.

In the table we have the mean results for each group of experiments.

Time interval	No. seconds learning	No. seconds relearning.	Gain in seconds	Percent gain	Probable error
19 Min.	1081	498	583	58.2	1
63 "	1106	647	459	44.2	1
525 "	1132	752	380	35.8	1
1 day.	1109	756	353	33.8	2
1 " .	853	599	254	32.6	2.2
1 " .	1184	803	381	34.6	2.3
2 days.	1154	854	300	27.2	2.3
2 " .	891	647	244	28.2	3.5
2 " .	1245	917	328	28.1	1.8
6 days.	1090	834	260	25.2	1.9
6 " .	872	652	220	26.1	4
6 " .	1306	989	317	24.9	1.6
31 " .	1115	892	223	21.2	1.3
31 " .	879	710	169	20.8	1.4
31 " .	1261	1007	254	21.1	2.7

This shows that the process of forgetting is rapid at first and then slower. After an hour interval so much has been forgotten that more than $1/2$ of the original work must be done again before the series can be reproduced. After 8 hours almost $2/3$ of the original work is necessary. But from that point the process of forgetting proceeds more slowly. After 24 hours the impression still retains about $1/3$ of its original strength; after 6 days $1/4$, after a month $1/5$. The ratio of what is retained to what is forgotten is inversely as the logarithm of the time. Immediately

after learning the material, memory is at its height; then it falls off rapidly, but more and more gradually loses this rapidity, as time passes.

From these results Ebbinghaus has computed a memory curve (See following page.)

Other experimenters have corroborated these results. F. Kuhlmann (40) has compiled the results of four experimenters, Henderson, Borst, Wruchner, and Stern.

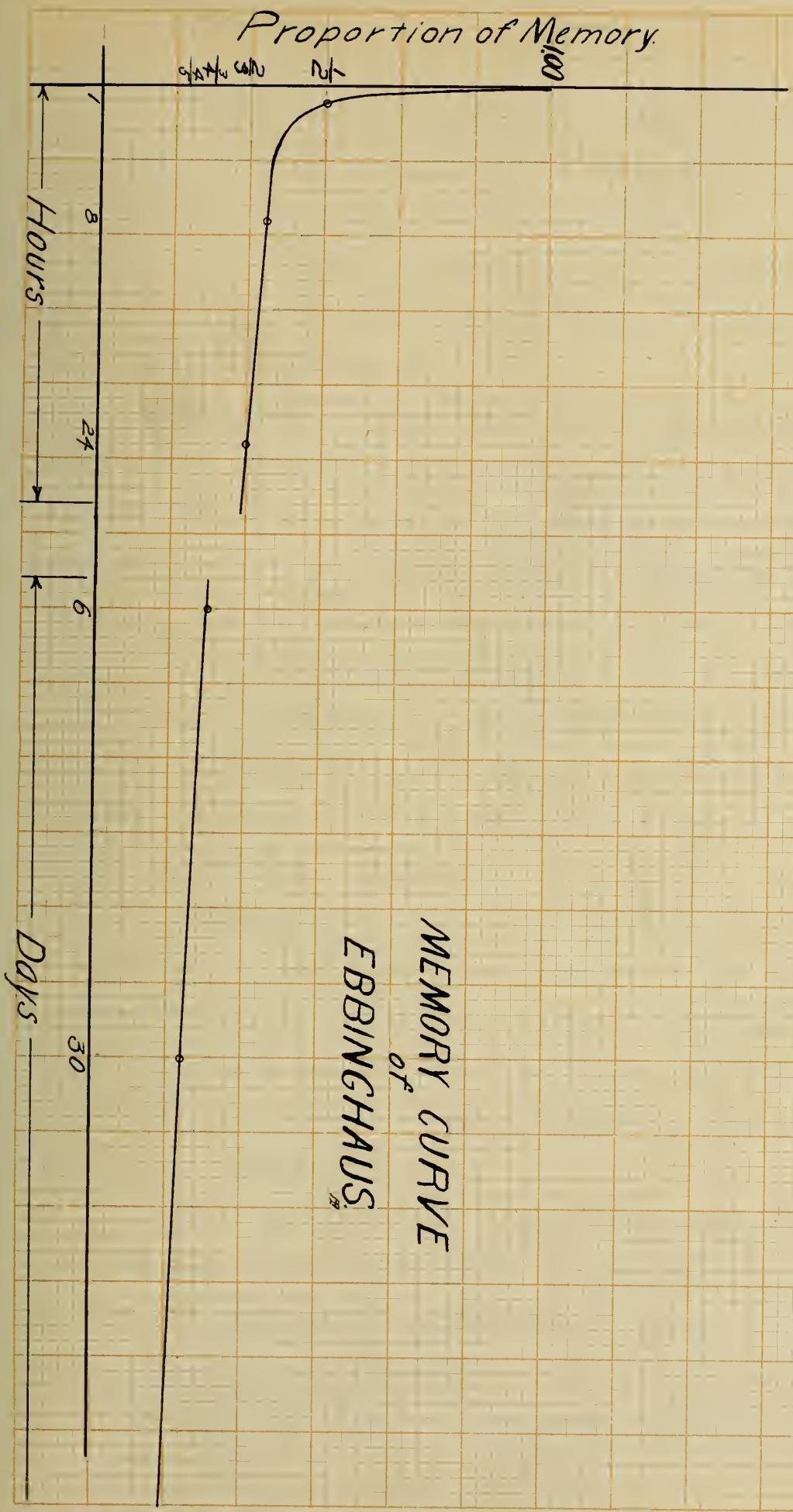
Henderson (32) read short passages of prose to his subjects and then asked them to write what they remembered of it immediately, after 2 days, and after 4 weeks.

Stern had his subjects describe a picture they had seen but once. The first trial was immediately after the picture had been shown, then later after 5, 14, and 21 days respectively. In a similar experiment by Wreschner, the picture was described from memory 3 times, after different intervals varying with the different subjects. In Burst's study of this problem, time intervals of 3 and 9 days were used.

Bringing together the figures from these several studies, F. Kuhlmann forms the following table to show the extent of memory illusion after different time intervals.

<u>RECALL</u>	<u>First</u>	<u>Second</u>	<u>Third</u>	<u>Fourth</u>
Henderson	105% (2 days)	27.6% (2 days)	28.5% (4 weeks)	—
Burst	11.5% (3 days)	12.1% (9 days)	—	—
Wruchner	5.8%	12.5%	28.1%	—
Stern	5.8% (immediate)	7.3% (5 days)	10.1% (4 days)	12.8% (21 days)

MEMORY CURVE
of
EBBINGHAUS



"These figures demonstrate clearly that memory illusion increases with time as well as does the amount that we forget entirely."

But these experiments are not in accord with some recent investigations that have shown an increase in memory reproduction after a certain interval.

Burnham, in his article on Retroactive Amnesia, (19) says that it takes time for an impression to become so fixed that it can be reproduced after a long interval; considerable time may be necessary for it to become part of a permanent store of memory. Persons receiving scalp wounds generally lose all memory of what took place for some minutes before the injury occurred. The incident of a farmer may be given as typical of such dissociations.

A farmer was thrown from his wagon and his head seriously injured. He lost all knowledge of what he had done for the several hours preceding the accident.

Burnham says "we may suppose there is a process of making a permanent impression upon the nerve cells, and also a process of association of organization of the new impressions with the old ones." The time required for this process may vary with different individuals and under different conditions, but "in all cases it seems to be necessary."

Such an interval of time for the "fixing" of the memory material the Germans have called the Perseverationstendenz. Meumann (50) states that after a 2 or 3 seconds interval, retention gains its greatest surety.

Wundt was the first to make a successful experiment com-

paring forgetting and the length of time interval between the learning and the reproduction. He found the best remembrance of the impression to be 1 1/2 to 2 seconds after the learning, not immediately after it.

E. J. Swift (69) tested the memory of a complex act. He trained his subjects in expert ball catching, and then after about 2 years' interval of no practice, he gave them tests to find how much they had lost of their previous skill.

In these tests he found the memory for the act was in no case inferior and in most instances it was superior to the scores made at the close of the regular practice.

Bourdon in testing the memory of certain processes after an interruption of training for varying periods of even greater length, found that there was no loss of skill, while in some instances there was an evident gain.

H. K. Wolfe investigated the memory for tones. He used nearly 300 vibrating metal tongues, giving notes through 5 octaves. A tone was given, and after a definite interval either the same tone was repeated or a higher or lower one was sounded. The subject wrote "same", "higher," or "lower." The difference of tone amounted to 4, 8, or 12 vibrations a second, and was kept constant during a group of experiments.

The main point of the experiment was to determine the influence upon memory of the time interval between the impressions to be compared. This was varied from 1 to 30, 60 and 120 seconds. Greatest accuracy was found when the interval was about 2 seconds. Between 10 and 20 seconds Wolfe found a point where forgetting

seemed to be retarded or to cease altogether. He concludes "the ratio of the right and wrong cases is inversely proportional to the logarithms of the time-intervals."

Ebbinghaus says there is a wave of better and worse judgments, periodic, 1, 6, 8, etc., seconds. The maximum of forgetting comes at about 60 seconds.

The means of retention and method of attention are different with different people. But the Ganz Methode has been found to be the best method of learning both for immediate and remote memory.

The child is less strong in direct memory than is the adult.

Rational material is better than the nonsense material for lasting retention with both children and adults.

Meumann (50) affirms that we only keep, as a rule, what we have intentionally attended to keeping. And he emphasizes the need for training in both immediate and lasting retention.

Lack of memory may be either inherited or due to lack of attention. The one case cannot be helped, but the other can.

SECONDARY CONDITIONS OF LEARNING.

1.- The effect of length of series:

Ebbinghaus (25) found in experimenting upon himself that a long series is more strongly impressed upon the mind by once learning, than is a short series. A series of 36 syllables is nearly twice as firmly impressed as one of 12 syllables. But he could generally repeat a series of 7 syllables after once reading them; sometimes he could repeat 8 syllables after one reading; while about

17 repetitions were required for a series of 12, and nearly 30 for one of 16 syllables.

2.- Effect of repetitions:

Repetition is an important factor in fixing an impression in the memory. It is mainly through repetitions that we memorize material; the other "helps" enter to diminish the number of repetitions needed.

3.- Effect of intervals between repetitions:

When there are a large number of repetitions needed, a suitable distribution of them over a certain interval of time is more advantageous than the accumulation of them all at once.

In learning 9 series of 12 syllables each, Ebbinghaus found that the same impression was made by 38 repetitions distributed over 4 successive days, as by 68 consecutive repetitions.

Ad Jost found that associations are stronger when formed by repetitions distributed with 24 hours interval, over several days. Jost formulates the law that "where two associations are of equal strength but of different age, a new repetition is of greater value for the older of the two." Müller, Pilzecker, Lipman, and others have verified this.

Meumann (50) states that with voluminous material the longer the intervals between repetitions, the fewer the repetitions needed.

4.- The rate of repetitions:

Ebbinghaus (25) says the quickest possible rate of reading or speaking is the most profitable, both for learning and for re-

learning.

Quantz reports that usually those who read most rapidly in learning, remember the most. But Ogden says the number of repetitions needed increases with the greater speed, and makes learning in this way unprofitable. While Whitehead (78) advances a rate corresponding to the beating of the pulse.

Miss Steffens observed that in learning sense material her subjects instinctively adopted a slower rate when endeavoring to memorize something more intensely.

Meumann (50) says there must be "adjustment of the rate of learning to familiarity with the material, and to the progress of the memory work." Meyerhardt (49) agrees with Meumann and adds "it is just as wrong to read uniformly slowly as to read always as rapidly as possible."

5.- The effect of simultaneous and successive presentations:

Münsterberg (53) considers the memory stronger for simultaneous than for successive presentations.

Hawkins (30) performed experiments to compare the relative strength of successive and simultaneous memory. He found that the older students and those more advanced could recall more objects when exposed simultaneously than when shown successively. And successive memory seemed much better for the younger pupils than simultaneous memory; with increase in age they improved in the power of the latter.

6.- The effect of associations:

According to Miss Calkins (20) the more readily associa-

tions are formed with the material, the better is the memory for the material.

Burnham (18) summarizes the study of association as follows:

"In the impressing and strengthening of a series of ideas by numerous repetitions of the same, inner bonds or associations are formed between all the individual members of the series. Every member of the series preserves a certain tendency in case of its return into consciousness to bring the other members with it.

"These bonds or tendencies are of different degrees of strength in several aspects. For the remote members of the original series they are weaker than for neighboring members; for definite distances backward, weaker than for the same distances forward. In case of increasing number of repetitions the strength of all the bonds increases."

Müller and Pilzecker (51) proved in their experiments that certain letters attract the attention more than others because of their quality or position in a syllable. They also proved that in recalling a line of poetry by means of some word given, we recall not necessarily what immediately follows, but frequently the first member of the line leading to the word given.

We form associations through contiguity, similarity, and contrast of impressions. The material may be associated because of some intrinsic relation, through mere mechanical bonds, or because it looks or sounds like other material.

And the more associations there are, the stronger is the hold of memory.

7.- Effect of rhythm:

It is extremely unprofitable to learn without rhythm. Experiments have shown that the suppression of rhythm makes learning all but impossible.

Margaret Keiver Smith has shown that, other things being equal, the syllables presented in simple rhythms are harder to learn than those which come in the more complex rhythms.

But it seems probable, from a wide collection of experimental data, that for each individual there is a certain rhythm that is peculiarly a help to him.

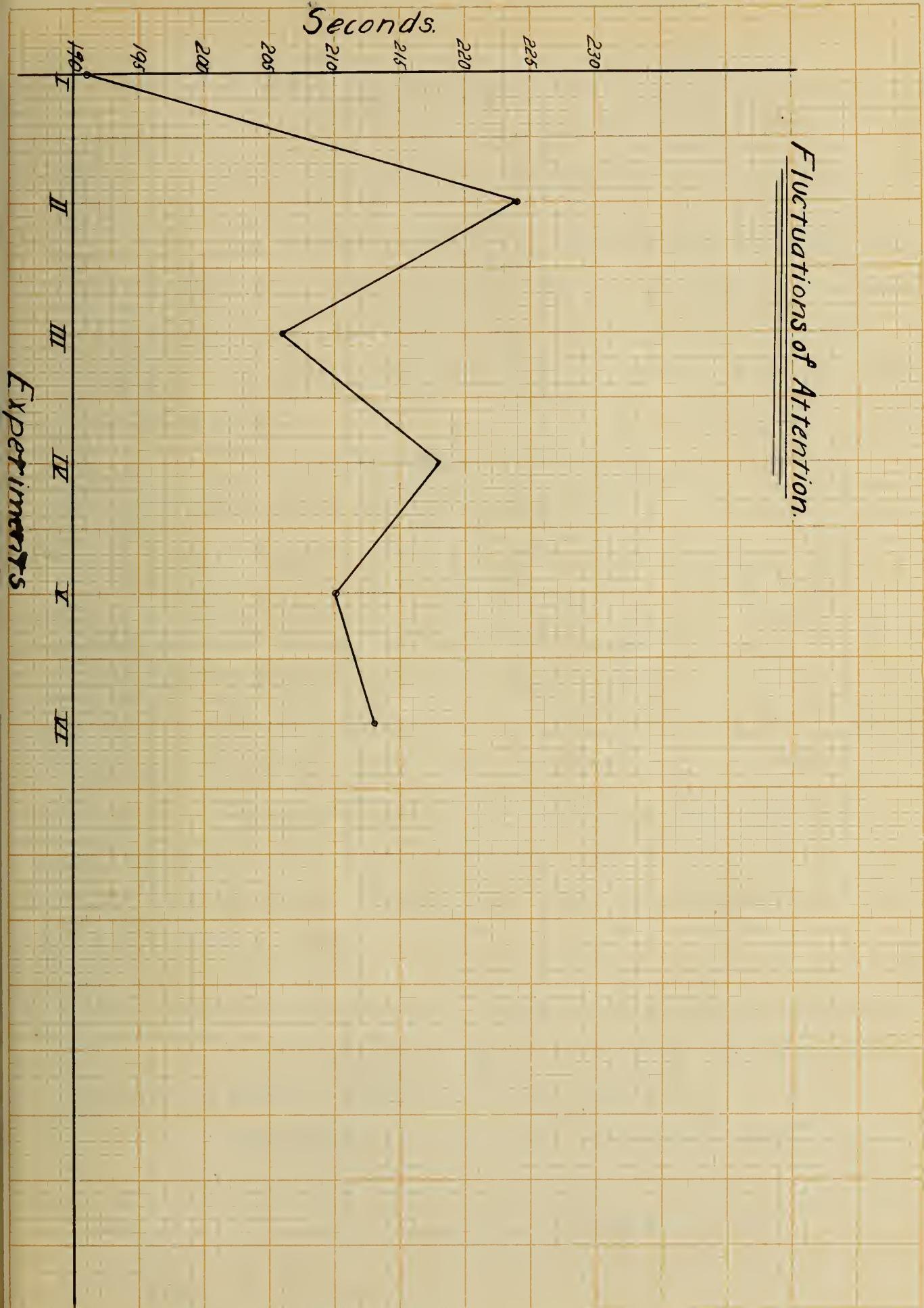
8.- Relation of attention to memory and the effect of fatigue:

Ebbinghaus (25) found indication of a remarkable rhythm of the attention. A series learned in a proportionately short time was followed as a rule by a series learned in a relatively long time. He says, "There seems to be a kind of periodic oscillation of the mental susceptibility or of the attention, in which the increasing fatigue appears in variations about a gradually shifting middle position."

In 84 experiments with 6 series of 16 syllables each, the mean time for learning the first was 191 seconds, second 224 seconds, third 206 seconds, fourth 218 seconds, fifth 210 seconds, and sixth 213 seconds. (See the diagrammatical representation of this series on the following page)

W. G. Smith (68) studied the relation of attention to memory and found that memorizing became poor in proportion as attention was withdrawn. He holds that the real explanation of effective memory lies in attention and interest.

Fluctuations of Attention.



Bain (6) says study is unavailing after fatigue and exhaustion.

9.- Time of day in its effect on memory:

Des Bancels investigated the variation of memory during the course of the day. He experimented upon himself at rising in the morning, and before and after the noon and evening meals. He learned a piece of 10 verses by the Ganz Methode and reproduced it 24 hours later.

The averages of his results were:

316.25 seconds needed in the morning.

348.75 seconds, before the noon meal.

340.71 seconds, after the noon meal.

345.90 seconds, before the evening meal.

280.20 seconds, after the evening meal.

He found fixation to be relatively rapid in the morning, and an increase of memory power after each meal.

Other experiments have shown that some people are "Morgan Menschen" as the Germans say. Others have a better memory in the afternoon or evening. And these persons may vary in different periods of life.

10.- The effect of using the different sense paths for memory:

The predominately visual type learns best by reading only, the auditory by means of spoken words, etc.

But except for persons who are predominately of one type, experiments (10, 21, 53) have shown that the memory is best when the different senses act together; they aid each other.

11.- Effect of loud, half loud, and low speech:

The experiments of Meumann (50), Pentschaw (59), and others, indicate for adults in general a half-loud learning as most favorable, for children silent learning, or with the voice repressed. In explanation of this we may say that children oftener than adults belong to the predominately visual motor type.

12.- Effect of the filled and unfilled time interval between learning and recalling:

W. G. Swift (71) performed experiments on the filling and length of interval. He used material that would do away with all associations as far as possible. 12 letters were arranged in 3 lines, one above the other, on a card. The subject was in a dark room and the card was illuminated for 10 seconds, then a pause of 2 seconds, and he repeated what he could remember.

Different distractions were used. The subject counted by twos to the beating of a metronome, speaking the numbers aloud, during the learning and during the pause interval. The beating of the metronome alone was no distraction. The greatest distraction was the addying, the next was the speaking, and the least distraction was found in tapping the table with the forefinger.

Swift concludes that it did not seem to matter whether there was an interval or not.

Bigham (10) says the longer the interval the greater the error, and filling the interval hinders the memory.

But in some recent experiments upon school children it was found that the filling of an interval between learning and reproduction improved the reproduction. The exact length of the

interval best for this improvement--Perseverationstendenz--was not definitely found. It seemed to vary with the different children and in the different experiments.

An important factor in memorizing is the significance of the problem and material. This differs with each occasion and each person. And these internal conditions are hard to discover.

PEDAGOGICAL RESULTS.

The methods of instruction in the school have not kept up with science and practical advance. The memory of the child to-day is absolutely neglected on the formal side. A bad practice would be better than none at all. If adults can be improved so much as we have found they are in laboratory experiments, children should be trained in this way and should have the attention and memory trained formally.

But the curriculum of the schools to-day is already overcrowded, so we cannot ask for the addition of a course in memory exercises. But, on the other hand, there is no reason to waste time on worthless material; special memory training can be joined to the material already in the schools. Emphasis can be placed on both the memory and the material to be remembered.

The question is frequently asked--To what extent does the training of anyone mental function cause improvement in other functions? To this I would answer that the extent of improvement in other functions is directly proportional to their "closeness" of relationship with the function trained. If (73) the ability to notice errors in arithmetic is directly correlated with the

ability to notice errors in spelling, then improved accuracy in arithmetic may involve improved accuracy in spelling.

That we do not know the relationship between mental functions, except in a very rough way, is partly due to the fact that these relationships are variable and partly due to lack of experiments. But we do know enough about these relationships to conclude with Thorndike (73) that the mind is not a functional unit, nor a collection of a few general faculties, but "a multitude of functions, each of which is related closely to only a few of its fellows, to others with greater and greater degrees of remoteness, and to many to so slight a degree as eludes measurement." "There is no memory to hold in a uniformly tight or loose grip the experiences of the past. There are only the particular connections between particular mental events and others, sometimes resulting in great surety of revival, sometimes in little."

And practice will develop memory on all sides. E. A. Kirkpatrick (37) says that no matter what line of development we follow it must influence the whole field. But Thorndike (74) considers "mere inner growth and maturity" as often the cause of improvement along certain lines, even when there has been special discipline along those lines.

The intensity and extent of concentration, the power of adaptation to the work in hand, speed in learning, and a manner of memorizing (50), all can be developed. According to Bagley (5) an ideal of memorizing can be developed, and he further asserts that the development of ideals is the chief work of education.

Complete memory would be all rounded development of all the senses of perception. The school should pay attention to this

fact. Foundations of memory must be laid in childhood (22), later, the same results cannot be reached.

The attention of the children should be keyed up; for then they learn more quickly and more surely. Disturbances often increase the attention for the material in hand. But a verse or other material that especially rouses the subject he learns easily and forgets easily.

William R. Wright (79) found from his experiments that:

(1) The subject accomplished more work when working under the mental stimulus of having a set task to be performed.

(2) A known impossibility to accomplish the required conditions tends to decrease the subject's total results.

Working in a class is a spur for effort. And the will helps. If we do not expect to go beyond a certain limit, we do not get beyond it.

Pestalozzi developed the concentration of his pupils by having them do simple hand work while they were studying and reciting.

The question is not so much what to study as how to study. The school is too material to-day. This material goal should be done away with. The question is how can the child most easily and simply learn to recite and retain.

Generally the student learns a poem piece by piece, then reads it all over and says the whole. The best way is to learn the whole at once. According to the most valuable experiments this "whole method" has been found to be quicker, surer, and more lasting. Meumann (50) proclaims this the most practical advance for learning. He says learning in pieces is the cause of stumbling recitations.

Let the child learn by the piece method until he is old enough to understand when shown the advantages of the whole method. After that he will do better with the whole or a mediating method.

The school brings out the different types to which the children belong.

Meumann was visiting a school when a boy was sent to the board to draw a map of Greece. He drew only a vague curve. The teacher became impatient, but Meumann had the boy trace the textbook map with his finger. Then the boy went to the board and drew a good map.

Meumann had recognized the boy as belonging to the motor type. Had the teacher understood how to treat the boy, she would have made things easier for herself as well as for the boy.

The type of the child's memory should be found by the teacher, and the child treated accordingly. After the teacher has determined the individual characteristics of each pupil, he should call the attention of the child to his own type, and show him how to learn in the best way according to that type.

Meyerhardt (49) suggests simple methods by which the teacher can determine the various types.

A number of phrases, words, or syllables, sufficient to fill a certain given length of time, is presented to the child, to ascertain whether he remembers the greater number of visual presentations or of auditory presentations.

Another method is to present letters or numbers in rows and columns. The visual minded will be able to recite the material of the rows and columns from right to left as well as from left to right, and from bottom to top as well as from top to bottom.

While this would be impossible for the auditory minded, since he learns in successive impressions.

But repeated experiments are necessary before the teacher can be sure of the type of the child.

After the child has developed his natural method of learning, the other sense paths of memory should be developed.

Rational memory has been found to be superior to mechanical memory. It takes about $1/10$ of the time to learn significant material that it takes to learn an equal amount of nonsense material.

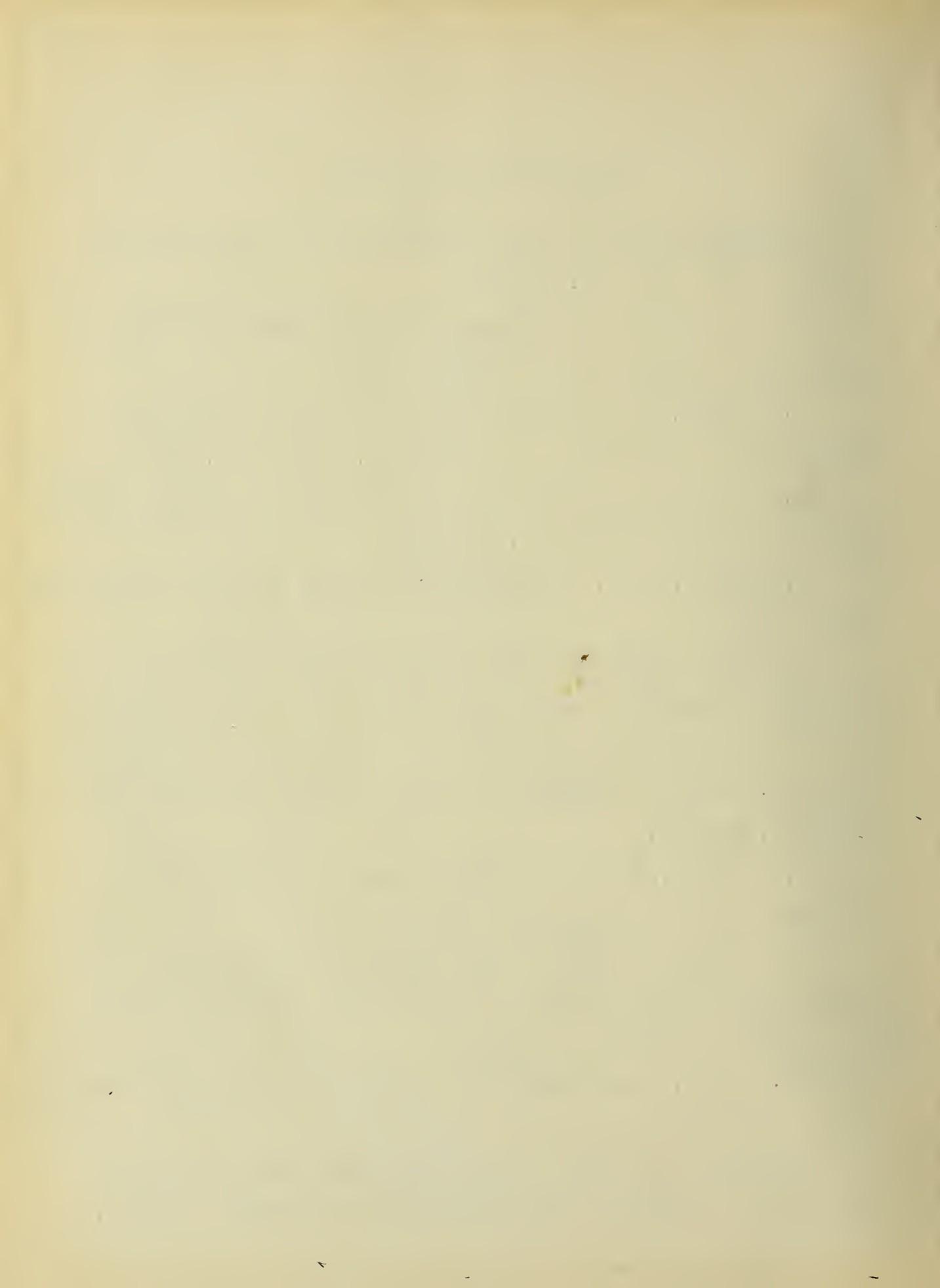
The best method of learning rational material is to first get an understanding of it, and then depend upon mechanical repetitions to "fix" it.

The teacher should help the child to get the content and suggest methods of association and grouping of the material, and then turn the mechanical memory into the right road.

There is a certain amount of material in the school curriculum that must be learned mechanically. This should come in the grammar school period; for mechanical memory comes then much more naturally and easily.

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